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VOLUME II. No. 4

(1) THE EVOLUTION OF VERTEBRAE
(2) THE OSTEOLOGY OF SOME AMERICAN PERMIAN VERTEBRATES. III

BY
SAMUEL WENDELL WILLISTON

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THE EVOLUTION OF VERTEBRAE

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In earlier papers I have discussed the evolution of vertebrae as based largely upon newly discovered facts in the structure of early amphibians and reptiles, establishing I think beyond reasonable controversy the original theory of Cope. New observations will make a summary of our present knowledge of service.

As is well known, a large and important group of the ancient Stegocephalia, the Temnospondyli, have peculiarly divided vertebrae, a heritage from the fishes, composed of elements which have received the names neurocentrum, hypocentrum, and pleurocentrum. Two groups were recognized by Cope, the Embolomeri and Rhachitomi, the former having the centrum composed of two subequal, notochordal disks, both supporting the arch or neurocentrum; the latter having the centrum composed of three wedge-shaped bones, the hypocentrum in front below, the divided pleurocentra above behind, all three supporting the arch. Of the Embolomeri not many forms are known. Beginning, so far as we yet know, in late Mississippian times, they gradually gave place to the more specialized Rhachitomi, becoming extinct in late Pennsylvanian or early Permian times. The Rhachitomi, derived from them in early Pennsylvanian times, comprise most of the known Stegocephalia of the Permian, disappearing or, what is more probable, giving origin to the Stereospondyli in the Triassic. In many ways these later Rhachitomi departed from the more primitive stegocephalian type in the palate, occipital condyle, and especially the vertebrae, retaining, however, most of their primitive characters. The reptiles doubtless arose in early Pennsylvanian or Mississippian times directly from the Embolomeri, retaining some of the primitive characters that were lost in all later Stegocephalia. Certainly it was from the Embolomeri that the reptilian vertebra arose, as was long ago contended by Cope, and the links of its evolution are now so complete as practically to amount to a demonstration.

The best-known embolomerous amphibian is *Cricotus* from the Permocarboniferous of Illinois and Texas, a belated and archaic type at the beginning of the Permian, one which retained the primitive structure of the vertebrae. By reference to the figure (Fig. 1, *A*, *B*, *C*) it is seen that the two elements of the body —the hypocentrum and pleurocentrum—are nearly equal in size, both half-centra, deeply amphicoelous and perforated for the notochord. In the evolution of the vertebral column, whatever may have been the cause, it is evident that its extremities changed

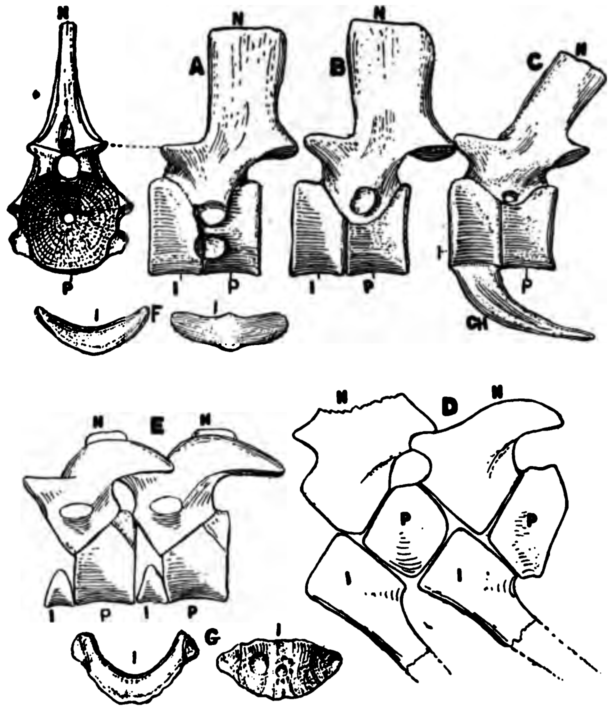

Fig. 1.—Vertebrae: *A*, *B*, *C*, *Cricotus*, dorsal, pygal, and caudal, from sides and below; *D*, *Eryops*, caudal from side; *E*, *Seymouria*, from side; *F*, *Dimetrodon*, dorsal intercentrum from behind and below; *G*, *Trimerorhachis*, from side and below; *I*, intercentrum; *P*, pleurocentrum; *N*, neurocentrum.

less rapidly than did the median portion—that is, the dorsal vertebrae. It thus happens that in the neck and tail some of the primitive characters have been retained in all higher vertebrates to a varying degree, though wholly absent from the dorsal region. The vertebrae of the anterior part of the column in the Rhachitomi had changed (Fig. 2) materially. The hypocentrum became a large wedge, with its base below; the pleurocentrum was divided into two more or less wedge-shaped bones, with their base above. And the Rhachitomi thus became absolutely excluded from any immediate ancestral relationship with the reptiles. But in the tail of *Eryops* (Fig. 1, *D*) and probably in other rhachitomous amphibians the change was much less complete, the pleurocentrum still retaining, in part at least, its primitive disklike notochordal character, though the hypocentrum had become typically rhachitomous, that is, wedge-shaped like those of the dorsal region, but still giving some support to the arch. This stage is clearly an intermediate one between the typically embolomerous and the rhachitomous types of vertebrae—the pleurocentrum embolomerous, the hypocentrum rhachitomous—and is in a measure paralleled in fishes, from the more primitive, ebolomerous type of the tail (*Eurycormus*) to the wedge-shaped half-disks of the dorsal region, though the pleurocentrum was not divided into two halves as in true rhachitomous vertebrae.

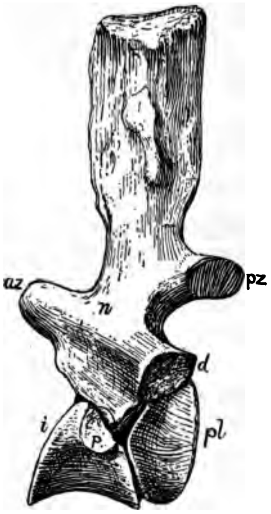

FIG. 2.—*Eryops*, dorsal vertebra from side: *pl*, pleurocentrum; *i*, intercentrum; *n*, neurocentrum; *az*, prezygapophysis; *pz*, postzygapophysis; *p*, parapophysis; *d*, diapophysis. (From *Cont. Walker Mus.*, Vol. I, No. 9, p. 201, Fig. 38.)

The next stage in the evolution of the reptilian vertebra is observed in the young of *Seymouria*, the most amphibian-like of all known reptiles, from the Lower Permian of Texas (Fig. 1, *E*), where the embolomerous pleurocentrum has increased in size, and the hypocentrum is more reduced, though extraordinarily large for the intercentrum of a reptile, and doubtless helping somewhat in the support of the rib. From this stage to that of the early reptiles of Permian times (Fig. 1, *F*) the change is relatively slight, consisting only in the further reduction of the hypocentrum to the intercentrum.

These various specimens, it seems to me, demonstrate the way that the reptilian holospondylous vertebra arose, by the gradual decrease of the notochordal hypocentrum to a subvertebral wedge only partly inclosing the notochord, and the increase of the notochordal pleurocentrum to the holospondylous, notochordal reptilian centrum supporting wholly the neural arch. And thus the earlier term intercentrum of Cope replaces the hypocentrum of Gaudry.

Dorsal intercentra, common to all known reptiles of early Permian times, early disappeared in most reptiles, persisting to modern times only in the gecko lizards and *Sphenodon*. But they remained in the neck to a greater or less extent in all reptiles, very few not having at least two, the first one in all Amniota as the "basal piece" or "body" of the atlas. And of course they are yet more persistent in the tail as the chevron bones, very few reptiles, like the snakes, utterly lacking them.

The first vertebra as it is usually numbered in the neck, the atlas, of the primitive reptiles (Fig. 3, *A*) it will be seen is only a slight modification of the amphibian caudal vertebra of *Eryops*, except for the absence of the exogenous chevron. The pleurocentrum is large and notochordal, the intercentrum is wedge-shaped, and both help support the neurocentrum or arch. The atlas, as it is called in mammals, has no motion whatever on its pleurocentrum—that is, the odontoid—and the latter has the same movement between it and the axis that the axis has with the third vertebra, its front end deeply concave and its centrum perforated or nearly so for the notochord, like the following vertebra. The second intercentrum, that between the centra of the atlas and axis, is very large, almost as large as the dorsal intercentra of *Eryops*, and like them gives support for the head of the rib. It is apparent that here at least the atlas is merely a modified

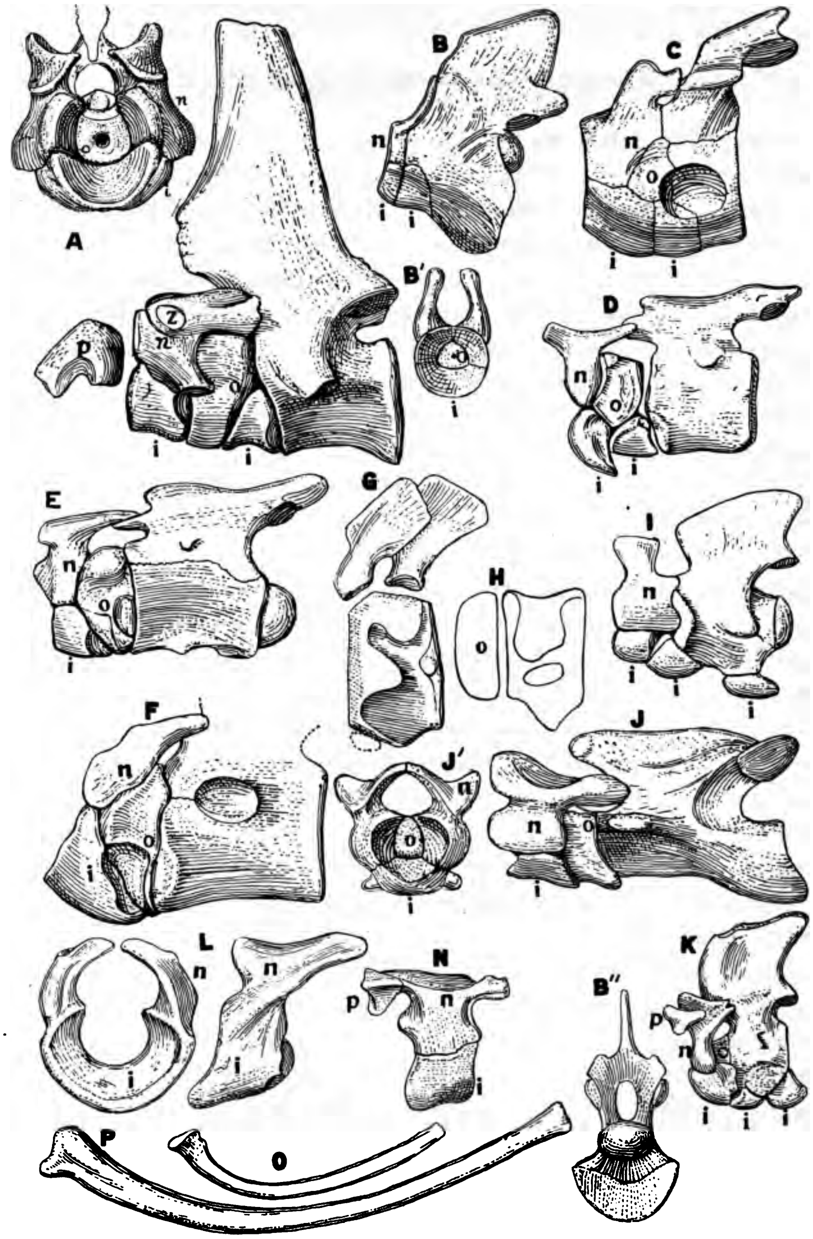

FIG. 3.—Atlas and axis: *A*, Theromorpha, ***Dimetrodon***, side and front; *B*, *B′*, *B″*, Pterosauria, ***Nyctosaurus***, side, front, and behind; *C*, Plesiosauria, ***Trinacromerum;*** *D*, Choristodera, ***Champsosaurus*** (Brown); *E*, Crocodilia, ***Gavialis;*** *F*, Crocodilia, ***Enaliosuchus*** (Jaekel); *G*, Ichthyosauria, ***Baptanodon*** (Gilmore); *H*, Ichthyosauria, ***Cymbospondylus*** (Merriam); *I*, Mosasauria, ***Platecarpus;*** *J*, *J′*, Chelonia, ***Testudo***, front and side; *K*, Rhynchocephalia, ***Sphenodon;*** *L*, Sauropoda, ***Diplodocus*** (Marsh); *N*, Predentata, ***Iguanodon*** (Dollo); *O*, ***Iguana***, dorsal rib; *P*, ***Trinacromerum***, dorsal rib; *i*, intercentrum; ***n***, neurocentrum; ***o***, pleurocentrum (odontoid); ***p***, proatlas.

embolomerous vertebra like the caudal vertebrae of the rhachitomous *Eryops*.

Cuvier long ago recognized in the so-called odontoid process of the axis of mammals the real body or centrum of the atlas, a view that was also held by Owen; and no one has since ventured to doubt the homology. One wonders under what theory of creation except evolution Cuvier and Owen could have explained how the transformation was brought about! In the human embryo the odontoid arises as a free cartilage perforated for the notochord.

As compared with that of the mammals the atlas remained rather primitive throughout the reptiles. Doubtless because of the perfect ball-and-socket joint between the skull condyle and the first vertebra there is less need for rotation between the axis and atlas than there is in the mammals. Whatever mobility the arch and intercentrum acquired upon its centrum or odontoid was limited usually to a horizontal movement—sometimes, as in the turtles, to a moderate degree of vertical movement. In relatively few types did the odontoid become fused with the axis.

In the Crocodilia it is seen (Fig. 3, *E*) that the odontoid is as large as in the primitive reptiles, possibly because of the loss of the second intercentrum. Nor has there been much change in its size and relation from the earliest known members of the order, though Fraas says that in the marine crocodiles of Jurassic times it was smaller. It bears the head of the axial rib because of the absence of the rib-bearing intercentrum, though more primitive in this respect in the early forms (Fig. 3, *F*). The odontoid is more reduced in the Pterosauria (Fig. 3, *B*), becoming finally invisible from the side. Here, as in not a few other reptiles, the atlas and the axis are indistinguishably fused in the adult, a condition carried to its greatest extent in the late Ichthyosauria, where the fusion is complete (Fig. 3, *G*), if indeed the atlas may not be wholly lost in some, as suggested by Merriam. The Triassic ichthyosaur *Cymbospondylius* (Fig. 3, *H*), however, still had a separate atlantal centrum. The Plesiosauria also have a complete fusion of the two vertebrae (Fig. 3, *C*) with a variable reduction of the odontoid, as seen from the side. The atlanto-axial ribs are also variable in this group; in the Cretaceous *Trinacromerum* but a single rib remained for the two vertebrae. Some turtles also have the atlas and the axis fused. In some (*Testudo*, Fig. 3, *J*) there is a limited motion of the atlantal ring upon the odontoid. The axial intercentrum in this order is often divided, sometimes fused with the odontoid, sometimes apparently wholly absent. In some dinosaurs (*Ceratopsia*) the first three or four cervical vertebrae are fused. In others the odontoid is small and more or less united with the axis, with probably some independent motion, like that of the lizards, between it and the ring of the axis in a lateral direction. In all reptiles there is at least an indication of the posterior zygapophyses of the arch of the atlas; in none is there an arthrodial articulation between the arch and the body of the axis as in mammals.

In many other reptiles, of which *Sphenodon* (Fig. 3, *K*), *Choristodera* (Fig. 3, *D*), and many lizards are examples, the odontoid is so much reduced that the atlantal and axial intercentra are contiguous below. In the singular and highly specialized burrowing lizard *Amphisbaena*, a figure of which is given herewith by the kindness of Professor Ruthven (Fig. 4), the atlas and the axis have attained a specialization seldom equaled among reptiles. The arch and the intercentrum of the atlas are closely united, the odontoid is fused with the axis, and the second intercentrum is absent. There is here considerable lateral movement of the atlantal ring upon the odontoid, as indeed is common in the lizards.

As stated, there are few exceptions to the rule that the second intercentrum is persistent among reptiles, and it is usually larger than the following ones when such are present. It is absent in the Crocodilia, the Anomodontia, some turtles, and some lizards; it is small in many dinosaurs and closely united with the axis. Jaekel has observed that the axial intercentrum was developed in the dinosaurs and other reptiles to fill out an otherwise unoccupied space below the odontoid.

Intercentra are generally persistent throughout the neck of lizards and mosasaurs, and throughout the dorsal region also in the geckos. Three or four intercentra persist in the Ichthyosauria, and as many in the Plesiosauria, where, as in the turtles, they may be double. They are unknown in the Therapsida, though probably persistent throughout in the few notochordal forms known. Except the second, free intercentra are unknown in the Dinosauria. Present throughout the column in the modern *Sphenodon*, they were probably present in the dorsal region in all the true Rhynchocephalia—that is, those with deeply biconcave or notochordal vertebrae.

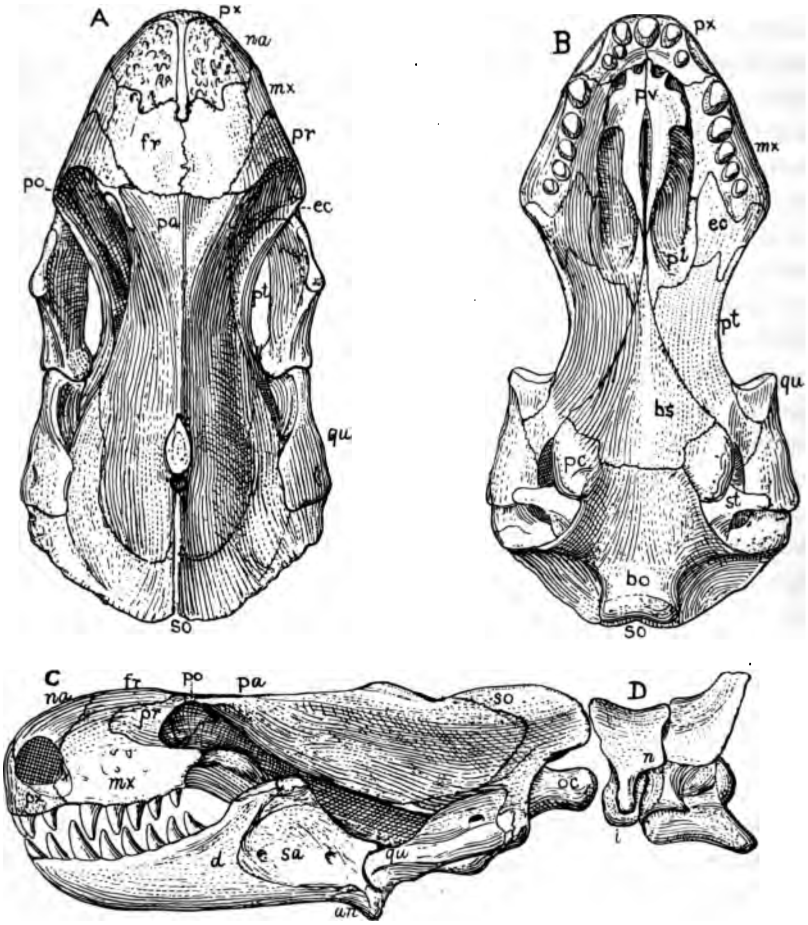

FIG. 4.—*Amphisbaena: A, B, C,* skull from above, below, and side; *D,* atlas and axis enlarged.

Proatlas.—The proatlas, first recognized and named by Albrecht in 1880,[1] is a small, more or less vestigial bone or pair of bones lying upon and in front of the arch of the atlas back of the occiput. It is believed to be the neural arch of a vertebra formerly intercalated between the atlas and occiput, and is often wholly absent in reptiles. It has been variously explained: by some as homologous with the arch of the so-called atlas of the amphibians; by others as merely the paired spine of the atlas; by Baur as the arch of a vertebra fused with the occiput; by yet others as the arch of a vertebra whose centrum is the anterior end of the odontoid. The latest theory is that of Jaekel:[2] that it is the arch of a vertebra whose centrum is the so-called intercentrum of the atlas—a theory necessitating the explanation of the second or axial intercentrum as merely a *Füllstück*, an *akcessorische* or *provisorische* ossification developed to fill out what would otherwise be an unoccupied space below the odontoid! Of these theories only the first or that of Baur is tenable—that is, that its centrum is either wholly lost or has become indistinguishably fused with the occiput. Baur based his opinion on an abnormality found in a specimen of *Platypeltis ferox*, a river turtle. This specimen, preserved in the collections of the University of Chicago, is figured herewith (Fig. 5). The arch of the atlas has an articular facet or zygapophysis on each side for articulation with the proatlas. Indeed the exoccipitals bear an extraordinary resemblance to the ordinary arch of a vertebra of which the basioccipital is the centrum. Of course it is by no means certain that this abnormality represents the primitive condition of the proatlas, but one cannot resist the conviction that it does. If such be the case, then the proatlas is nothing more than the dissociated posterior zygapophyses of the basioccipital vertebra—and this is another theory. The objection to it is that it calls for an independent center of ossification for this part of the arch. In this specimen there is not the slightest indication of a fused centrum between the basioccipital and the atlas. Moreover, the arches of the proatlas, if such they be, spring directly from the exoccipitals, apparently their normal posterior zygapophyses.

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[1] *Zoöl. Anzeiger*, p. 450.

[2] *Anatom. Anzeiger*, 1912, p. 610.

Evidences of the proatlas have been discovered in various members of the Cotylosauria, but no complete specimens have yet been obtained; it was doubtless present throughout the order. It was present in many if not all Theromorpha and has been detected in various Therapsida. In *Dimetrodon* and *Ophiacodon* of the former order (Figs. 3, *A*, 6) it consists of a pair of small bones articulating in front with a facet on the exoccipital, behind with a true zygapophysis on the anterior part of the atlantal arch, both surfaces looking more or less downward. It may be mentioned that the exoccipitals in the Theromorpha are rather slender bones, extending on the sides of the foramen magnum nearly to its top, rather loosely united with the paroccipitals and supraoccipital—that is, they are quite like the exoccipitals of the abnormal specimen of *Platypeltis*, aside from the proatlas.

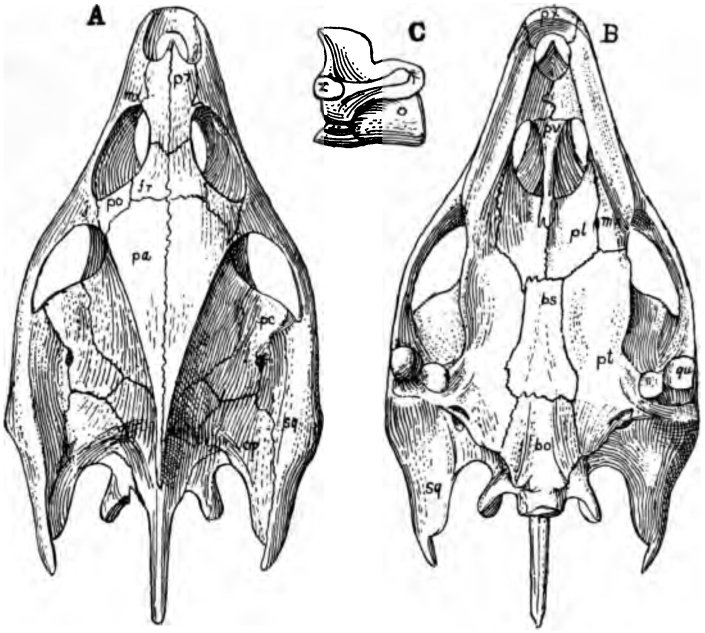

FIG. 5.—*Platypeltis ferox: A*, *B*, skull from above and below; *C*, atlas and axis

In the Crocodilia, as far back as the Jurassic, the proatlas is a single, roof-shaped bone in the adult, arising from paired cartilages, but not articulating with either occiput or atlas. Paired bones have also been observed in various genera of the Dinosauria of all the chief groups. They have been observed in the theropod *Plateosaurus* of the Triassic, in *Iguanodon* and other genera (Fig. 3, *N*) of the Predentata, and were originally called the "postoccipital" bones in the Sauropoda by Marsh. A roof-shaped, unpaired proatlas has been recognized in the Jurassic *Rhamphorhynchus* of the Pterosauria. It has long been known in the modern *Sphenodon* (Fig. 3 *K*), and has been reported in the chameleon lizards and the mammals *Erinaceus* and *Macacus*. Doubtless it will yet be found in other extinct reptiles, though certainly absent in some.

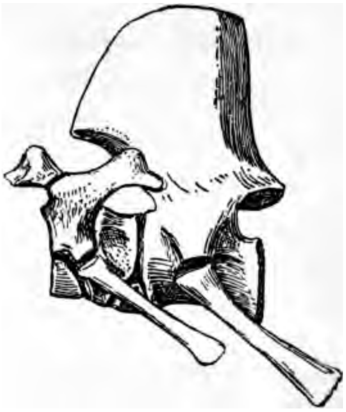

FIG. 6.—*Ophiacodon*, proatlas, atlas, and axis.

THE OSTEOLOGY OF SOME AMERICAN PERMIAN VERTEBRATES. III

SAMUEL W. WILLISTON
University of Chicago

ERYOPS Cope

The cranial structure of *Eryops*, as a type of the temnospondylous amphibians, has engaged the attention of several able paleontologists.[1] Each has added something new to the solution of the problem and subtracted something from the results of previous writers. Excellent material has induced me to review their conclusions. Nor shall I be an exception to the rule of addition and subtraction! Possibly the next writer on the subject will continue the rule, so far as I am concerned, though I have ventured to make no conclusions where the evidence does not seem positive. *Eryops* material has accumulated in the Walker Museum since Professor Case's first collections in Texas more than twenty years ago, but the chief part has been obtained within the past ten years by parties in charge of Mr. Paul Miller of the Museum. I have not attempted to count the specimens, but there are about twenty trays full and five mounted skulls. For the purpose of study, however, reliance has been placed upon a few which have in no way been restored or mended.

It is needless to say that the brain of *Eryops* is very small in comparison with the size of the skeleton, the largest measuring not more than twenty-two millimeters in greatest width and forty from the foramen magnum to the pituitary fossa, and about twenty in greatest height, or altogether scarcely more than one cubic inch in capacity. Numerous figures are given, made with care by myself, which will convey a better idea of the cranial structure than could lengthy descriptions.

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[1] Huene, *Bull. Amer. Museum Nat. Hist.*, XXXII (1913), 318; Broom, *ibid.*, p. 579; Watson, *ibid.*, XXXV (1916).

Figs. *A–E* of Plate III are from a skull collected by Mr. Miller, which is of especial value for the determination of the parts, in that it is almost free from matrix and the sutures are nearly everywhere plainly visible. Fig. *A* shows the basicranial portion as it is separated, broken only through the epipterygoids, exoccipitals, and parasphenoidal rostrum. The almost perfect symmetry of the two sides conclusively indicates the character of the margins.

In front the troughlike parasphenoid is seen from which the ethmoid or sphenethmoid is broken away a little in front of the pituitary opening. On either side of the opening the cerebral surface is bordered by a diverging margin, free for a short distance, probably the lower border of the optic foramina. Back of the infundibulum there is a narrow transverse ridge in the middle, the summit of the dorsum ephippii. From this ridge the lateral margins curve outward and backward and slightly upward to opposite the epipterygoid. The whole of this ridge is apparently sutural, especially so since the two sides are exactly alike where they have separated from the thin, lateral cranial wall, the postoptics. Posteriorly the sutural margin thickens and then ends in a narrower, free border at the junction of the basisphenoid with the proötic, doubtless for the foramen for the fifth nerve. In the middle the cerebral surface descends in a smooth spout-shaped cavity to the free, cartilaginous end of the basisphenoid. On either side the flaring, concave cerebral surface is turned a little more backward, extending beyond the middle part and giving attachment at the sides to the proötics. Beyond the basisphenoid-proötic articulation the thin lateral basioccipital articulation for the proötics is broken away in this specimen. In the middle there is a short space between the posterior end of the basisphenoid and the front end of the basioccipital which remained cartilaginous. In the present specimen it is considerable, but in others the front end of basioccipital reaches quite to the basisphenoid, leaving only a small space above filled with cartilage in life. Posteriorly on each side are quite symmetrical rugosities for the cartilaginous lower end of the paroccipitals, which united with the postoptics only at the thin lateral wall.

Back of the cavities for the paroccipitals the exoccipitals are broken through, on the left side almost on the level with the floor of the brain cavity between them, disclosing the whole of a canal passing from the outer side into the brain cavity near the middle of the exoccipital as shown in the figure. The opposite surface of the break is shown in Fig. *E*, a small intervening fragment from the outer side lost. The orifices of this canal I find in every specimen examined and doubt not that it is for the passage of the twelfth nerve, whose existence is disputed by Huene and Watson but recognized by Broom.

On the right side the break is higher up, showing on the outer side the articular surface for the paroccipital, with a cavity between them opening on the back part of the exoccipital pedicle for the passage of the vagus. The middle portion between the exoccipitals is definitely shown to be the basioccipital in longitudinal section (Fig. 14), but I have not been able to determine definitely the external sutural margins.

The supracranial surface of this same specimen is shown in Fig. *E*, Plate III. In the middle the smooth, gently concave cerebral surface shows on each side a small foramen. The lateral otic cavities are largely filled with a rugose mass of imperfectly ossified bone, the paroccipitals, that on the left side lying directly upon the similar surface shown in the Fig. *A*—that is, the sutural surface of the exoccipital—from which it is evident that the proötics do not reach quite to the superior supraoccipital side. Apparently connected with the front end of this cavity is a foramen which opens laterally a little distance above and back of the stapes, as shown in Fig. *F*. Possibly, however, this foramen communicates with the large cavity partly above the otic cavity, opening laterally on the occipital surface.

The under surface of this specimen (Fig. *B*) shows clearly the lateral margins of the parasphenoid anteriorly, not extending as high on the basipterygoid processes as in some other specimens.

Even better in some respects is specimen No. 1260, as shown in Figs. *F*, *G*, *H* of Plate III and *F*, *G*, *H* of Fig. 14. A front view of the middle part, made before sectioning the specimen is shown in *F*. It is made a little obliquely from a little back of the parietal foramen and behind the attachment of the epipterygoids through the pituitary fossa. The structure here is quite the same as in the previous specimen. The dorsum ephippii with its lateral margins for the postoptics is quite like the other. In this specimen they apparently unite at the sides with the inner sides of the epipterygoids, leaving a vacuity below between them; in the other specimen they are separated throughout. The back part of the pit for the insertion of the upper ends of the epipterygoids and the attachment of the postoptics is shown above, the stapes laterally, with the opening of the foramen already mentioned.

The left half of this specimen is shown from below in Fig. *G*, the pterygoids separated, with the perfect stapes in position. The latter is also shown in large size and horizontal in Fig. *H*. It is co-ossified with the proötic by a slender head, dividing the foramen from the otic cavity into two, the anterior one doubtless for the passage of the seventh nerve, the posterior for the eighth. An anterior projection or head in front of the opening for the seventh nerve articulates with an edge of the proötic. Posteriorly, directed upward and backward, a projection, like the tubercle of a rib, fits into a depression of the paroccipital much as in the contemporary reptiles. Just beyond the tubercle is the orifice of the canal for the arteria perforans. The stapes lies immediately below the paroccipital throughout, articulating at its extremity with the tabular, and probably continued by a cartilaginous extremity to the quadrate.

A third specimen, Fig. I, collected by Professor Case, is of interest because it is the only one observed in which the alisphenoids or postoptics are preserved. This thin bone lies immediately within the epipterygoid as it was observed by Broom. It articulates close to the lateral margin of the upper ends of the epipterygoids. In front it is continuous with the lateral thin walls of the presphenoid rostrum, leaving a foramen at the sides opposite the pituitary opening about six millimeters in diameter, the optic foramen. Whether there is a distinct suture separating the postoptic from the ethmoid I cannot say, as the thin bone here is cracked. The postoptics have no connection with the proötics unless it be at the front margin of the foramen for the fifth nerve. In median section (Fig. 14, *F*) the sutural lines of the basisphenoid, parasphenoid, and basioccipital seem quite evident. The parasphenoid extends back in the middle, as shown by the sutural line in Fig. *B*. The basioccipital in this specimen, at least (1260), reaches narrowly quite to the basisphenoid. The pituitary fossa differs materially in depths in different specimens. In one (110) there is a large and deep cavity in front of the dorsum ephippii broadly open across the middle, with a distinct pituitary cavity in front opening into it. In others the pit is more shallow, largely divided in the middle by a carina from the overhanging bridge, with only a small communication between the two sides and without a distinct pituitary pit in front of it.

As Broom has shown, the large parasphenoidal rostrum broadening anteriorly is composed for the most part of loose bone with four canals piercing it in front (Fig. 16, *E*, *F*), opening laterally in front of the orbits, and communicating with a large median cerebral cavity behind, the whole firmly co-ossified with the skull roof. The lower part of this rostrum is clearly formed by the parasphenoid, which may be traced easily back nearly to the condyles and on the sides in front and behind the basipterygoid processes. *Eryops*, however, seems to be an exception to other Permian amphibians and reptiles. In *Cacops* (Fig. 16, *G*) the rostrum is hollow throughout, with a thin wall of bone surrounding the cavity not united with the skull roof above. The lower part of this is probably the parasphenoid, though much reduced in amount. The thin walls surrounding the cavity must be the ethmoid.

Very interesting is the fact that this structure of *Cacops* is that of some, probably all, of the contemporary reptiles. I have shown the similar structure in *Pantylus*. It is that also of *Diadectes*, *Sphenacodon*, *Varanops*, and *Mycterosaurus*. I doubt not that it is the common structure of all. There was no ossified interorbital septum in any early reptile.

In lateral view (Fig. 14, *F*, *G*, *H*) the otic cavity is freely open. Posteriorly the rugose floor shows that it was largely filled with cartilage in life, but anteriorly—that is, in the proötic part—the cavity was hollow, probably shut off from the brain by a membrane only. Certainly it did not contain cartilage, since in every one of the four or five specimens I have examined the basioccipital floor is quite smooth, sharply delimited from the rugosity of the paroccipital.

Opening from the side exteriorly is the large oval foramen, partly divided by the co-ossified head of the stapes into the two foramina for the seventh and eighth nerves. I confess that I cannot find anywhere the triradiate union of the supraoccipital proötic and paroccipital mentioned by Watson, and unless other specimens are different from all those at my command there could have been no internal ossified wall of the otic cavity. It was doubtless separated from the brain proper in life by a simple membrane.

The cross-sections *G* and *H* show the views anteriorly and posteriorly with the course of the proötic-basisphenoid suture. I can find no sutural separation between the proötic and paroccipital, though of course it must have passed through or near the auditory opening. If the thin walls extend to the roof, it must have been very narrowly. The whole anterior surface of the proötic was free, with a narrow opening between it and the postoptic, continued as far forward as the posterior sutural margin of the basisphenoid at its junction with the proötic.

Broom's determinations of the bones of the occipital surface are essentially correct. The dermosupraoccipitals do not, however, extend to the upper margin of the foramen magnum. Whether the exoccipitals meet narrowly above the foramen is very doubtful; not a trace of a median suture can be found in any specimen. I believe that the supraoccipital forms the upper margin in the middle. Neither can I trace the sutural separation of the upper end of exoccipital quite as Broom figures it, nor the union of the tabular and dermosupraoccipital at the inner end of the lateral occipital vacuity. The epipterygoids lie broadly upon the pterygoids, forming the broad upper extension of the wings. In one specimen only (234) do I find satisfactory indications of its extent. In others, even in sections, I cannot distinguish the two bones. Evidently they are firmly co-ossified in adult life.

CHENOPROSOPUS Mehl

An additional specimen collected during the past season by Mr. Paul Miller affords some important additions to our knowledge of this interesting genus of amphibians. The type specimen of the genus came from a sandstone layer immediately underlying the Miller quarry on Poleo Creek, New Mexico, and was but little distorted. The present specimen, which unfortunately includes only the skull, is from a horizon six or eight feet above that of the type and but forty or fifty feet distant. It was inclosed in a clay matrix, and in consequence is flattened and broken. The right posterior part, when found, was protruding from the previous year's excavation, made for me by a laborer, and a considerable part of it was lost.

The specimen is a little larger than the type, but its identity is assured by the complete agreement in proportions and structure so far as they are comparable. Possibly it belongs to a different species, but species of these fossils are elusive and indistinguishable from the accidents of preservation.

The palatal surface of the specimen, as preserved, is shown in Fig. 7, *A*, about one-third natural size; the restored skull from above and below in *B*. Fortunately the preservation of the basicranial bones permit, with the aid of the type specimen, the determination of the posterior width of the skull almost exactly, a little greater than was suspected for the type specimen, in which the right posterior part had been somewhat injured. The upper surface of the specimen is preserved, except for the lost portion, nearly complete, showing the free inner border of the quadrate.

The palate, it is seen from the two figures, is merely an elongated modification of that of *Eryops*. The internal nares are much longer, the interpterygoidal space much narrower, but the teeth resemble closely those of *Eryops* and have the same insertions. Two small teeth are present on the premaxillae immediately behind the marginal row in the middle; such teeth are usually absent in forms referred to *Eryops*, but I have observed them in one skull, which may, however, be generically distinct. These characters of the teeth remove the genus widely from *Cricotus*, with which at one time it was thought to be closely allied. The parasphenoidal rostrum, as in *Eryops*, is broad in front, but has a sharper inferior border throughout than in that genus, much as it is in *Cacops*. A little in front of the basisphenoid it is hollow with thin walls. It is probably hollow throughout as in *Cacops* and most other genera; it is crushed too flat to be composed, as in *Eryops*, of bony tissue with small canals in it.

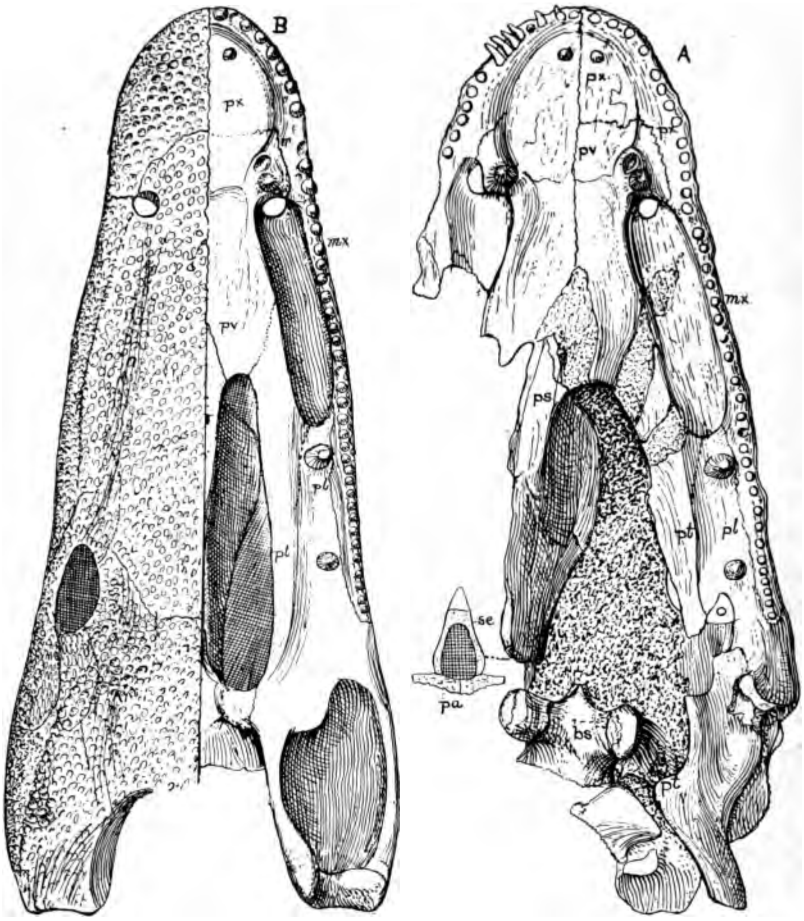

FIG. 7.—*Chenoprosopus:* *A*, skull from below, as preserved; *B*, skull from above and below, as restored.

The dorsal side shows the same structure as that of the type, the small nares situated far back, as also the small orbits. So far as the sutures can be made out, they agree essentially with the determinations of Mehl, and are probably throughout like those of *Eryops*. One important point is evident, however: there is no closed otic notch, as was suspected in the type specimen.

Altogether the structure of the skull, so far as it is determinable, is like that of *Eryops*, and the genus, at least until the remainder of the skeleton is discovered, may find its proper location in the Eryopidae, amply distinguished by the external and internal nares. In the same quarry, and in the Baldwin quarry of approximately the same horizon, rhachitomous intercentra occur, some of which doubtless belong with *Chenoprosopus*. There are, however, evidences of other genera of amphibians in these deposits, some of them of small size, and it may be long before the full amphibian fauna of the New Mexico Permian deposits are satisfactorily known, since the exposures are very limited in extent.

NAOSAURUS Cope

The close relation if not identity of the genera *Edaphosaurus* and *Naosaurus*, long ago suspected by Case, was established by Williston and Case in 1912 by a specimen from New Mexico.[1] The type specimen of *Edaphosaurus* unfortunately included only the imperfect skull and a single vertebra, the axis; that of *Naosaurus* (*E. claviger* Cope, as limited by Hay in 1902) a series of vertebrae without the skull. Because of the greatly elongated spines of the vertebrae Cope unfortunately associated with it the skull of a *Dimetrodon*, and the error was perpetuated for years. Several skulls of *Edaphosaurus* are now known, including a very complete one from Texas in excellent preservation. The determination of the sutures, however, has been difficult, and even yet several are doubtful. The type specimen of *E. pogonias* Cope has been repeatedly studied by Case, Broom, Huene, and Watson, but no restoration is quite satisfactory, though that of Watson is much the best.

[1] *Carnegie Publication No. 181*, p. 71.

While no valid characteristics distinguishing *Edaphosaurus* from *Naosaurus* have yet been found in the skulls or appendicular skeleton, there is a well-marked difference in the spines of the cervical vertebrae, which, it has seemed to me, will justify the retention of the name *Naosaurus*, the later-described form. In several forms, presumably species, which may confidently be referred to *Edaphosaurus*, and among them the type species, the cervical spines are slender and pointed, while in *Naosaurus claviger* they are broadly dilated and thickened at the extremity, and it is upon this character that I recognize the genus. Furthermore, so far as our present knowledge goes, *Edaphosaurus* seems to come from a lower horizon in Texas and New Mexico than *Naosaurus*, which is confined to Texas so far as definitely known, though fragmentary specimens from the Dunkirk beds of Ohio and the Rothliegendes of Germany and Russia may prove to have the distinctive spines of *Naosaurus*.

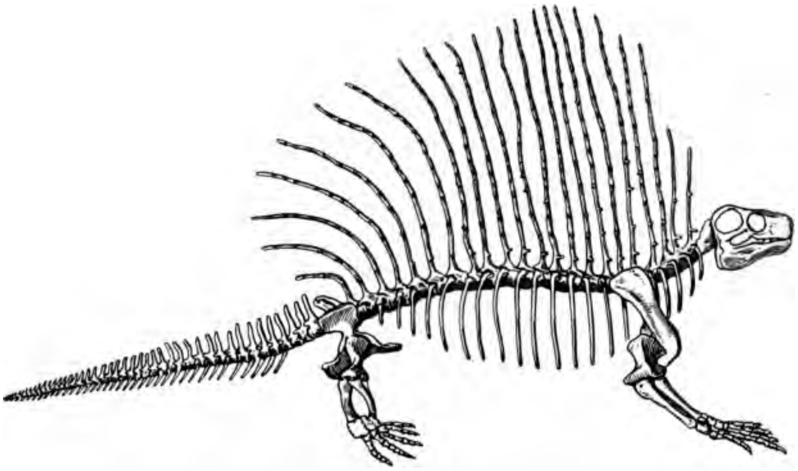

FIG. 8.—*Edaphosaurus*, restored skeleton from mounted specimen in Walker Museum.

In the spring of 1916 Mr. (now Lieutenant) Josiah Bridges, assisting Mr. Paul Miller in Texas, discovered a specimen of *Naosaurus claviger* largely exposed and disintegrated, but connected with the skull—the first definitely known of the species.

The specimen comes from the same horizon as that which I have frequently mentioned, the one from which the specimens of *Seymouria*, *Trimerorhachis*, and *Labidosaurus* described in previous papers occurred. Unlike those specimens, however, the present one was in soft red clay and only slightly incrusted in the usual nodular matrix. Recognizing its extreme rarity and value, Mr. Miller used the utmost care in its collection, infiltrating the mass thoroughly with shellac before attempting its preparation. As a result the specimen is in good condition, showing but slight distortion. The supraorbital roof of the left side is somewhat depressed, and the right quadrate is crowded slightly forward. The slender temporal arches and some of the thin borders of the right mandible, the only one preserved, could not be recovered. Otherwise the skull is complete and for the first time in the family shows the whole palate in an undistorted condition. In addition to the skull the spines of several cervical vertebrae and numerous fragments of other spines and centra, together with a complete humerus and the two somewhat incomplete scapulae, were recovered.

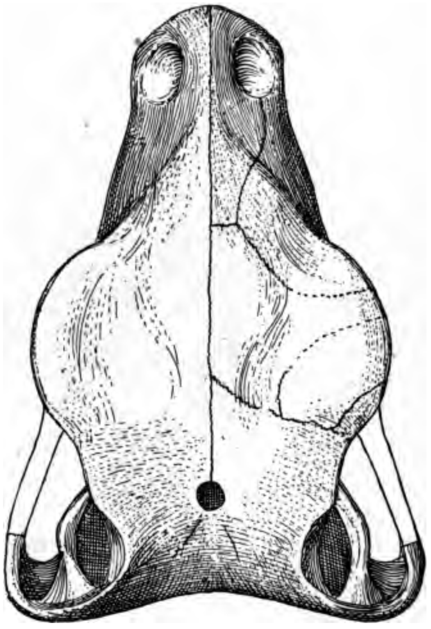

FIG. 9.—*Naosaurus claviger:* Skull from above. Two-fifths natural size.

At my request Mr. Bridges, then a student of paleontology at the University, undertook the study and description of the specimen, but his call to service prevented its completion. A year ago Professor Douthitt, of the University of Kansas (Ph.D. University of Chicago, 1916), found in the Clear Fork beds of

Texas a remarkable specimen of the same species, composed of a complete series of connected vertebrae to the base of the tail, various ribs, and the pelvis, all in excellent preservation. Dr. Douthitt had begun the description of this specimen and would have completed Mr. Bridges' notes and figures of the skull had he lived. Unfortunately his untimely death in October has prevented the fulfilment of the task. The specimen collected by Dr. Douthitt will later be figured and described by one of Dr. Douthitt's students who was associated with him in its study. Altogether the material now known will permit a faithful and accurate restoration of the skeleton except, as usual, the extent of the tail and some details of the feet.

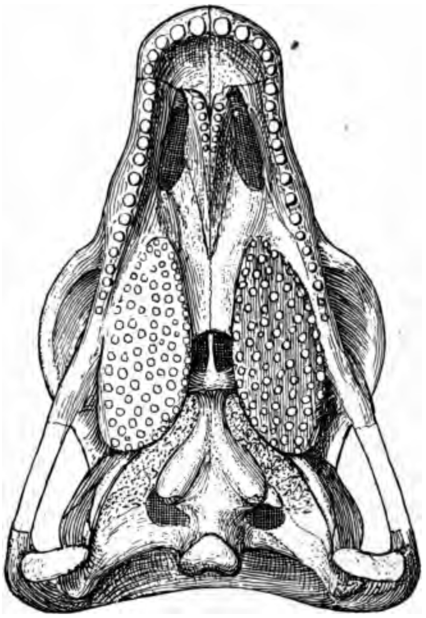

FIG. 10.—*Naosaurus claviger:* Skull from below. Two-fifths natural size.

I have given much care to the drawings of the skull (Figs. 9, 10, 11). In the top and bottom views no corrections have been made except to modify the slight obliquity of the left side. The outlines are practically tracings from the specimen. The anterior part of the side view is made from the right side, the posterior part from the left. The palatal outlines have not been changed except to correct the slight lateral displacement of the quadrates.

In comparison with the skull of *Edaphosaurus pogonias*, as figured by Williston and Case (*loc. cit.*), the chief differences, it is seen, are the broader shape and less compressed nasal region. The nares seem to be larger, but that may be in part due to the lack of preservation or the loss of the septomaxillae. The sutures throughout, as usual, are determinable with difficulty. However, those of the sides of the face are clearly visible, not only agreeing on the two sides, but also with similar markings on the skull of *E. pogonias*. The continuation of the lacrimals to the nares is a primitive character unusual in the Theromorpha. The sutures between the jugal, postorbital, and squamosal cannot be distinguished. If these sutures are located as they are supposed to be and as they appear to be, the Edaphosauridae are a startling exception to all other known theromorphs or cotylosaurs in the separation of the postorbital squamosal arch above the temporal opening, agreeing in this respect with the more specialized cynodonts of the Therapsida. There can be no question but that the opening in these genera is morphologically identical with that of *Dimetrodon*—that is, the lower one—thus seeming to establish the identity of the therapsid arch.

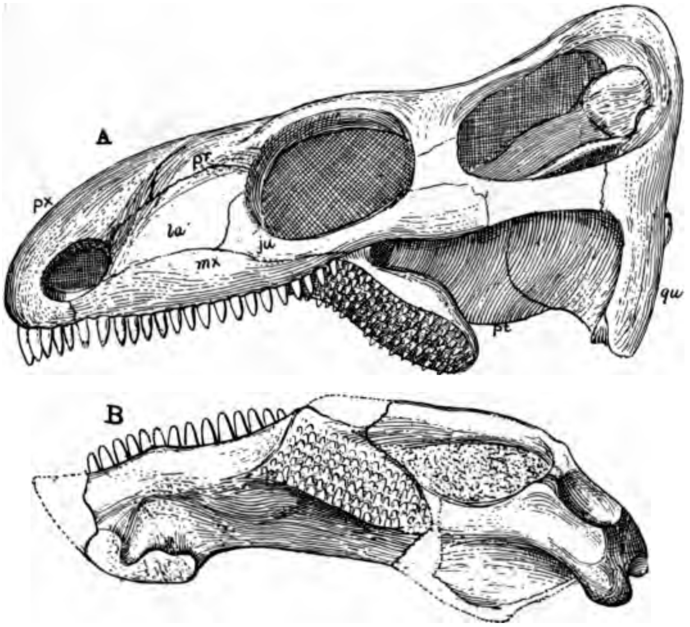

FIG. 11.—*Naosaurus claviger: A*, skull from side; *B*, right mandible. Two-fifths natural size.

Nor can the sutures in this specimen be made out on the top of the skull, though certain indications seem to corroborate the arrangement of *Edaphosaurus*. Watson has represented the prefontal as a small bone, but I think that he is in error. The figure of the frontal bone given in the cited paper confirms the interpretation of Williston and Case.

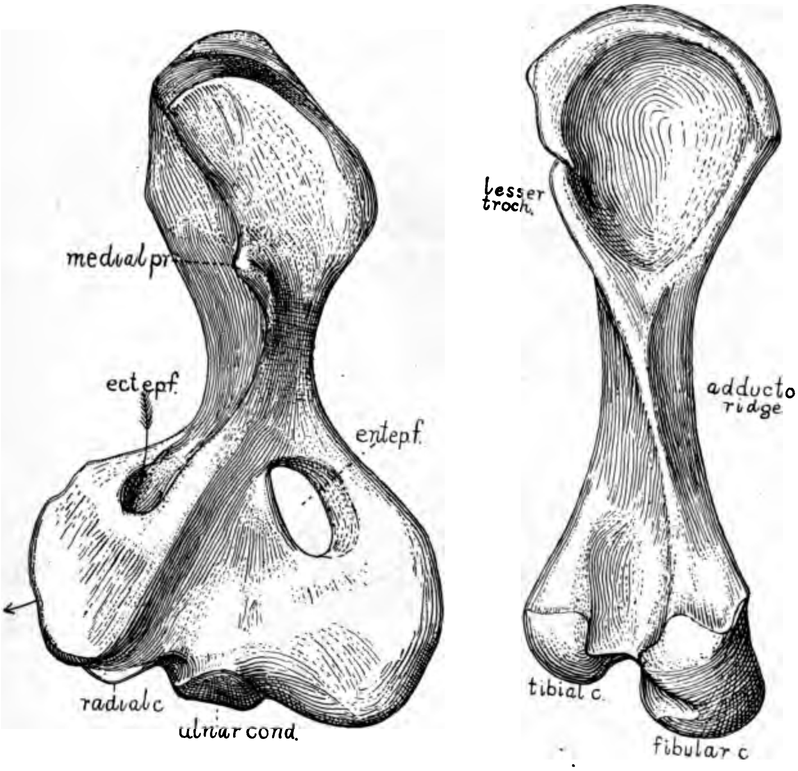

FIG. 12.—*Naosaurus claviger:* Left humerus, dorsal side, and right femur, ventral side. One-half natural size.

The parietal foramen, as usual in early reptiles with extensive palatal teeth, is large. I cannot identify the quadratojugal, unless it is situated, as in *Dimetrodon*, chiefly on the posterior side of the quadrate. Nor can the arrangement of the occipital bones be made out with certainty above. Doubtless they are quite as in *Edaphosaurus*.

Among the material in the Brier Creek bone-bed associated with the mounted skeleton of *Edaphosaurus* (Fig. 8) there were collected a number of macerated bones of the skull, including the jaws, palatal bones, and especially a very perfect occipital bone here figured, nearly natural size (Fig. 14). At the upper part of the supraoccipital a distinct rugosity shows clearly the shape of the interparietal bone, and its comparison with the specimen of the figured skull of *Edaphosaurus* makes evident the relations of the parts here, about as Watson has figured them, though smaller. The median bone seems to be unpaired, articulating each side with the slender bone originally identified by Case as the tabular. When

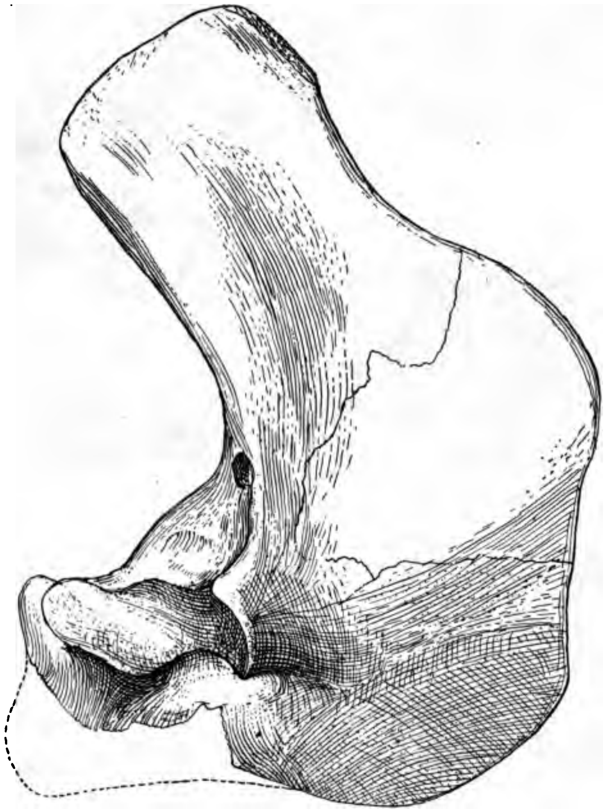

FIG. 13.—*Naosaurus claviger:* Right scapula-coracoid. Two-fifths natural size

one knows what to look for, the same structure can be found on the other side of the specimen.

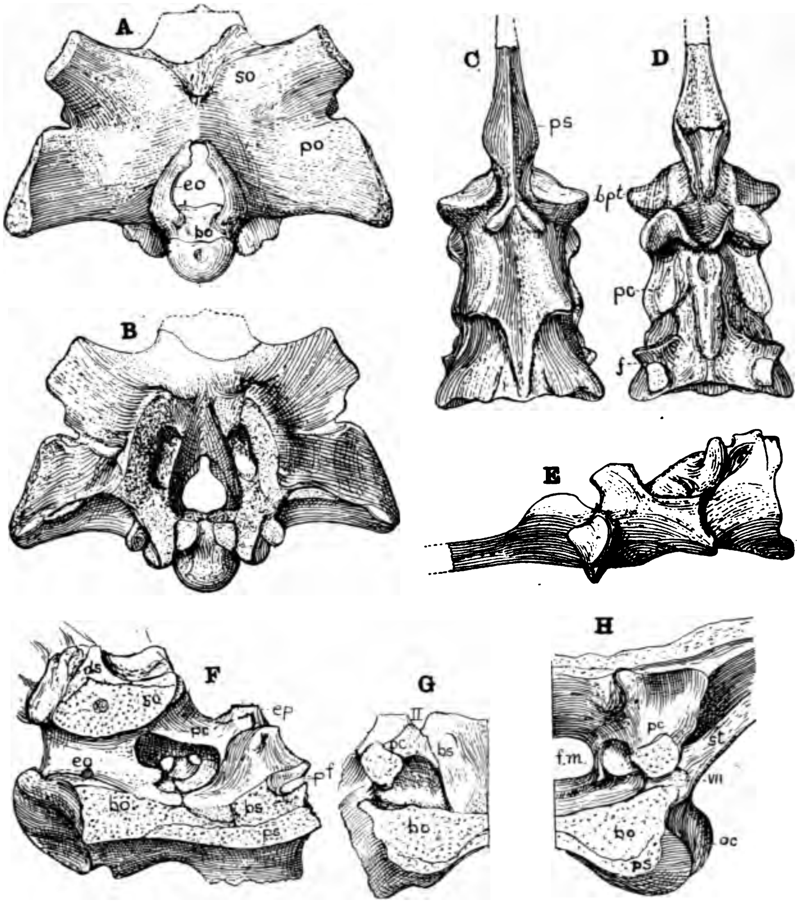

FIG. 14.—*A*, *B*, ***Edaphosaurus***, occipital complex, from without and within, natural size; *C*, genus indet. basiphenoid, from below; *D*, the same from above; *E*, the same from side, natural size; *F*, *G*, *H*, ***Eryops***, basicranial bones, longitudinal and transverse sections; *so*, supraoccipital; *po*, paroccipital; *eo*, exoccipital; *bo*, basioccipital; *pc*, proötic; *bs*, basisphenoid; *ps*, parasphenoid; *st*, stapes; *ep*, epipterygoid.

The exoccipitals are clearly distinguished in this as in other specimens, being composed of two slender bones firmly united with the basioccipital, nearly surrounding the foramen magnum, but not united to the supraoccipital or paroccipital. On the cerebral side the proötics have been macerated away, showing the upper or supraoccipital part of the otic cavities confluent with the cerebral. The notch between the supposed supraoccipital and the paroccipital leads into a distinct groove which pierces the side of the cerebral cavity for the passage of a nerve, probably the seventh. A considerable rugosity on the posterior side of the paroccipital shows the location of the stapes, which has not been figured in this family. A fragment of the outer end still connected with the quadrate indicates a large bone, as in *Dimetrodon*.

In this connection may be described an interesting specimen from the Brier Creek bone-bed which has puzzled me for a long time (Fig. 14). It is a separated basisphenoid almost as perfect as a recently macerated specimen. Though associated with the *Edaphosaurus* remains, it is too large to belong with that genus, nor can it be referred to *Dimetrodon*. The front end of the specimen is continued into the parasphenoid, showing distinct sutural surfaces above for the sphenethmoids which inclose the anterior prolongation of the cerebral parts in most if not all of the early reptiles. Back of their articulation a groove leads into the bowl-like pituitary fossa, flanked on either side behind by the short and stout basipterygoid process. Posteriorly on the under side are small basisphenoid processes, behind which there is evidently an overlapping sutural surface for the basioccipital. On either side of the cella turcica there is a rounded margin for the exit of nerves. Back of them are strong ascending processes, very much like those of the crocodiles, doubtless also for the articulation of the postoptics. A deep and long rugose pit on each side back of these processes lodged the proötics, its posterior surface ascending vertically and separated from another articular face by a groove, probably for the passage of the eighth nerve. In the middle between the proötic pits the cerebral surface is narrow, with a small pit anteriorly. Posteriorly the surface is hollowed into a deep bowl, its irregular border forming a semicircle. The bone is solid, without internal cavities or canals

The scapula of *Naosaurus* herewith figured (Fig. 13) has been completed in a few details from the specimen first figured by Case and later by Williston and Case, which agrees exactly both in size and in shape with the scapulae of the present specimen. The humerus also, it is seen, is quite like that of *Edaphosaurus* as figured by Case (Fig. 12).

For the present, then, if the genus *Naosaurus* is accepted, its distinction lies exclusively in the shape of the anterior-cervical spines.

SPHENACODON[1] Marsh

In the summer of 1916 my son and I collected from the Miller "bone-quarry" in the vicinity of Arroya de Agua, New Mexico, the skull and considerable part of a skeleton of *Sphenacodon*, a brief description of which, with restoration, was published the following November (*loc. cit.*). At the time it was hoped that further exploration of the deposit would yield additional parts of the skeleton, but the hope has not been fulfilled, though excavations by Mr. Miller and Mr. Williston during the present year have brought to light part of another skeleton of the same genus and species.

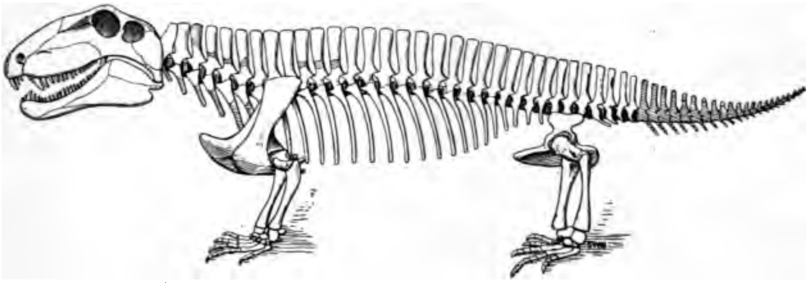

FIG. 15.—*Sphenacodon:* Restored skeleton

The skull of *Sphenacodon*, as has been said, is so very like *Dimetrodon* that were it found in the Texas *Dimetrodon* deposits, without other parts of the skeleton, it would be unhesitatingly referred to that genus. In its study I have compared five or six more or less complete skulls of *Dimetrodon* and am unable to find any characters which might be considered generic. Perhaps the skull and mandibles are a little more slender, and there may be fewer teeth, and it is not at all improbable that when more perfectly perserved skulls are obtained generic characters will be found.

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[1] Marsh, *Amer. Jour. Sci.*, XV, 1878, 410; Baur and Case, *Trans. Amer. Phil. Soc.*, XX, 1894, 4; Case. *Publ. No. 55, Carnegie Institution*, 1907, 67; Williston, *Amer. Perm. Vertebrates*, 78; *Proc. National Acad. Sci.*, II, 1916, 650; Case and Williston, *Publ. No. 181, Carnegie Institution*, 1912, p. 61.

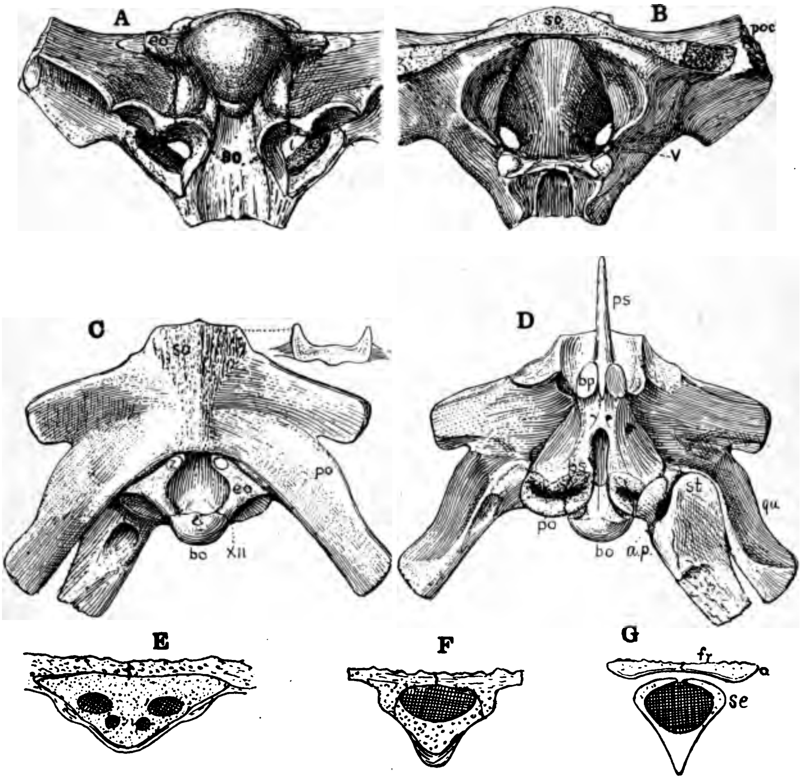

FIG. 16.—*A*, *B*, *C*, *D*, *Dimetrodon*, occipital complex: *A*, from below; *B*, the same from above; *C*, obliquely from behind; *D*, the same from in front; *E*, *Eryops*, section through parasphenoidal rostrum, near front part of orbit; *F*, *Eryops*, section through parasphenoidal rostrum near base; *G*, *Cacops*, section through parasphenoidal rostrum at middle of orbit.

The skull from which the figures are made is very nearly complete and but little distorted. The premaxillae in front of the nares and the front ends of the mandibles were protruding from the previous excavation when found, and had been destroyed. Their loss is less to be regretted, however, in that in the same quarry various parts of the skull, including the complete mandible with teeth and the premaxillae, were found belonging unquestionably to the same genus and species. In the side view of the skull the premaxillae, mandibles, and teeth have been restored or completed from other specimens, and the shape of the orbit has been modified slightly to agree with undistorted specimens. The side of the face in front of the orbit, as usual in *Dimetrodon* skulls, composed of very thin bone, is in part destroyed, so that the entire course of the sutures separating the lacrimal cannot be determined. The temporal opening is well defined on both sides, as is also the course of the sutures of the surrounding bones, which agree closely with those of *Dimetrodon*. In lateral view the quadratojugal is very small, as in *Dimetrodon*, barely touching the extremity of the jugal.

The slight compression of the skull is corrected in the upper view from a very complete and undistorted specimen of *Dimetrodon*, with which it closely agrees in proportions, the sutures everywhere plainly visible in both. As usual, the post-orbito-squamosal bar has been slightly separated from the squamosal, leaving a small foramen, but as the adjacent surfaces are clearly sutural there can be no possibility of an upper temporal opening. The frequency of this separation in skulls of the pelycosaurs is very suggestive of the way in which the supratemporal opening originated.

In the posterior view the dermosupraoccipital (interparietal) and tabulars are clearly defined, quite agreeing with specimens of *Dimetrodon*. The former is a rather narrow transverse bone undivided in the middle, overlying the supraoccipital and uniting on the sides by an oblique suture with the tabulars. The tabular is an elongate bone, lying below the inner margin of the posterior prolongation of the parietal, reaching quite to the extremity of the paroccipital. Von Huene has thought that he recognized the supratemporal forming the continuation of the parietal process between the tabular and squamosal. At one time I, too, thought that I recognized the bone, but unfortunately in each of the three skulls in which a dividing suture seemed to be present it is in a different place—so different that I am now very skeptical of its occurrence in any pelycosaur. As Huene identifies it, its distinguishing suture is in the position represented in the figure (Fig. 18) by dotted lines on the left side. Nor would one expect to find the supratemporal persistent in any theromorph, inasmuch as it seems quite certain that it had begun to disappear among the

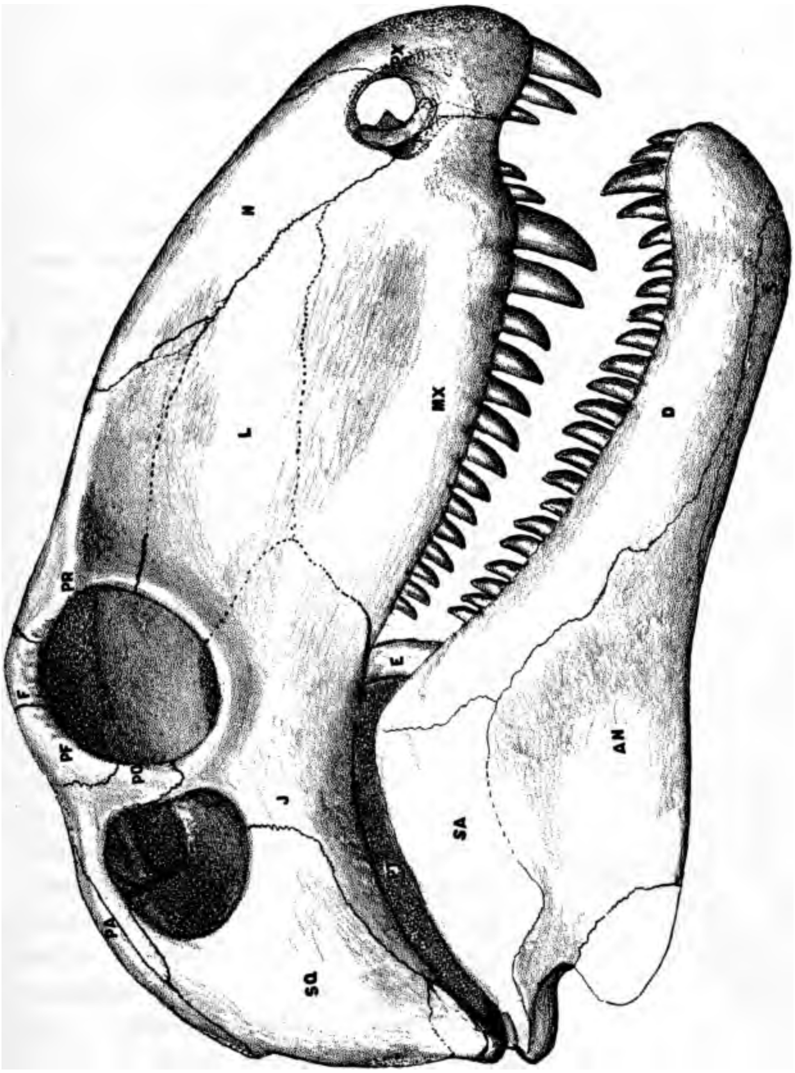

FIG. 17.—*Sphenacodon:* Skull from side, one-half natural size; *PX*, premaxilla; *N* nasal; *MX*, maxilla; *L*, lacrimal; *PR*, prefrontal; *F*, frontal; *PF*, postfrontal; *PO*, postorbital; *PA*, parietal; *SQ*, squamosal; *J*, jugal; *SA*, surangular; *AN*, angular; *D*, dentary; *S*, splenial.

contemporary cotylosaurs, the Captorhinidae. In no other genus of the Theromorpha has its presence been satisfactorily determined.

The stapes is also well shown in the occipital view. Its relations are as shown in *Dimetrodon* (Fig. 16) except that it diverges more from the paroccipital, directed downward and backward nearly to the pterygoid articulation, and is longer. Probably this is also the real position in *Dimetrodon*. Its proximal end is so crowded between the paroccipital and basisphenoid as to be indistinguishable.

A fortunate fracture across the frontal bone shows a cerebral canal, triangular in shape, bounded by thin walls resting upon the broad vertical prolongation of the presphenoid or parasphenoid, a structure apparently common to all the tetrapods of the Permian. Perhaps these plates fused in later reptiles to form the mesethmoid, but one thing seems certain: in none of these early reptiles was there a complete interorbital septum.

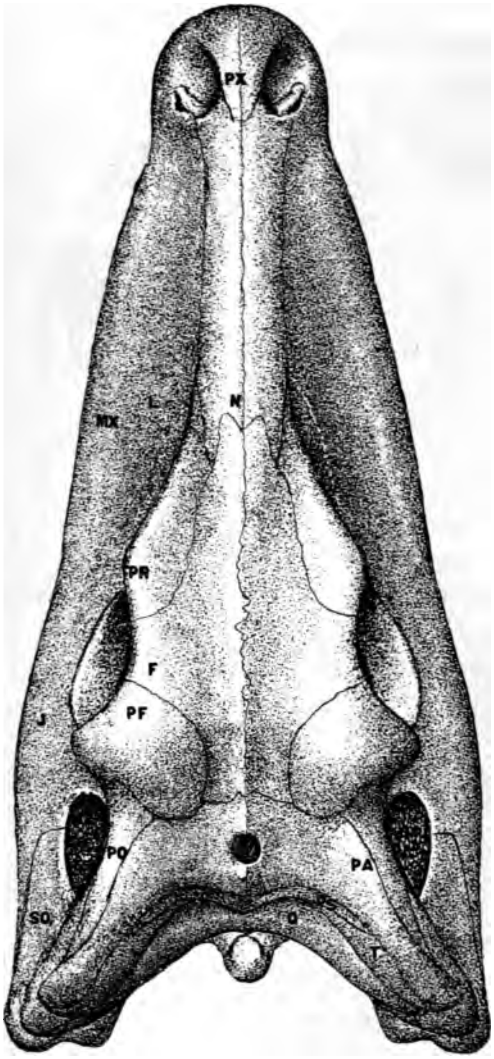

FIG. 18.—*Sphenacodon:* Skull from above, one-half natural size; *T*, tabular; *DS*, dermosupraoccipital; other explanations as in Fig. 17.

The palate, so far as it is visible between the mandibles and as studied before the parts were united, is identical with that of *Dimetrodon*. The stout transverse part is crowned with six rather strong teeth, and the pterygopalatines and prevomers in front are covered with small conical teeth.

To repeat, the structure of this skull throughout, in comparison with several skulls of *Dimetrodon*, show such identity of structure that the figures may serve almost equally well for both genera.

Closely connected with the skull is a series of twenty-five presacral, three sacral, and four pygal vertebrae, closely united save for a break back of the eleventh vertebra, where in an interval of a few inches a single centrum and two connected spines were found, fixing the presacral series at not less than twenty-seven vertebrae, with the possibility of one more. The arch of the atlas is like that of *Dimetrodon*, as shown in the figure (Fig. 1, *A*). Lying between their front ends and the occiput are fragments of the two proatlantal arches. The axis, as shown in this and other associated specimens, is also quite like that of *Dimetrodon*.

The vertebral spines beyond the axis are of nearly uniform length to the base of the tail. Those of the neck increase a little, both in stoutness and in length, to the beginning of the dorsal region above the scapula, where they are the longest of the series. They decrease very slightly in length posteriorly, becoming thinner and less stout, markedly so at the end of the presacral series. The first four of the caudal series, pygals, as seen from the figures, are not only much more slender, but are beginning to shorten rapidly. And their centra are also much smaller than those of the dorsal region, all of which indicate a short and weak tail.

The dorsal ribs are relatively slender and not much curved and are, for the most part, unusually long. The ribs of the fifteenth vertebra, for instance, each measures more than ten inches. Inasmuch as the depth of the body is fixed by the girdles, these long ribs show a relatively broad trunk. The width of the body back of the forelegs could not have been less than twenty inches or equal to about one-half of the length of the body from head to tail. The ribs of the cervical and anterior dorsal region articulate by well-differentiated head and tubercle to the intercentral space and end of the prominent diapophyses. Near the middle of back the ribs are less markedly dichocephalous and their movability was less. At the seventh or eighth presacral vertebra they begin to show sutural union with the diapophysis and a facet on the front end of the centrum. At the fifth presacral the ribs were fixed and immovable. As in *Dimetrodon* the ribs extend quite to the sacrum, the first presacral pair having an expanse of not less than six inches. I am confident that the body of both *Sphenacodon* and *Dimetrodon* was broad and flat, an explanation perhaps of the relatively short tail.

As figured in the restoration (Fig. 15) the living reptile was about five feet in length. Possibly the tail was a foot longer. Other specimens or species of the Yale collection indicate reptiles of seven or eight feet in length. The genus *Sphenacodon* is known only from the valley of the Puerco in Rio Arriba County, New Mexico. Specimens from Texas, at one time suspected of belonging to this genus, have been identified since as *Theropleura*.

Clearly the genus represents an earlier phylogenetic stage than does *Dimetrodon*, and as clearly they both belong in the same family, originally called the Spenacodontidae by Marsh.

PLATYOPS PARVUS, Genus and Species New (Diplocaulidae)

Fourteen years ago Broili described and figured[1] a very small skull which he referred to a distinct species of *Diplocaulus* under the name *D. pusillus*. So different was it from the typical *D. magnicornis* that he was assured of its relationship chiefly because of the position of the orbits and the characteristic sculpture of the cranial roof bones.

This species has been provisionally retained in the genus *Diplocaulus* chiefly because of the great variations which have been observed among the specimens referred to this genus, nearly every one, as Douthitt has truthfully asserted, appearing to be a different species. With a greater accumulation of specimens I am confident that, aside from the two recognized species from Texas, *D. magnicornis* and *D. limbatus* and probably also *D. Copei* Broili, several others will be recognized among the material now known. The only problem will be to distinguish ontogenetic from specific characters.

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[1] Paleontographica, Vol. LI, p. 24, Pls. VI ff., 1–4, 1904.

Fragments of very small amphibians have long been observed associated with the remains of *Lysorophus*, but seldom have they been complete enough to determine their relationships. Recently two excellent skulls were found by Mr. Miller in the Craddock bone-bed near Seymour, Texas, which show all the essential characters of the Diplocaulidae, but which to unite in the genus *Diplocaulus* is to disregard all taxonomic characters. They are of precisely the same size, measuring twenty-two millimeters in length from the tip of the face to the condyles, and are twenty and twenty-two millimeters in greatest width just back of the articulation of the mandibles. I propose for these specimens the generic and specific name *Platyops parvus*. *D. pusillus* Broili is evidently congeneric; possibly future material will unite them specifically. Aside from the vast difference in size, the proportions of the basicranial bones and the short tabular horns will at once distinguish the genera. The palatal surface in both specimens is quite perfect and undistorted. Singularly both are quite alike in lacking the parasphenoidal rostrum between the pterygoidal openings, the parasphenoid terminating in a pointed process, alike in the two specimens. It is premature to say that this is not an accidental character and that other specimens will not show the complete bar, but I cannot resist the conviction that its absence is not an accident.

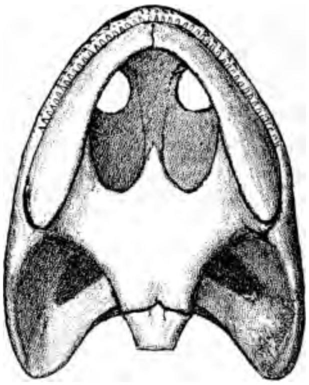

FIG. 19.—*Platyops parvus:* Skull from below, a little less than twice natural size.

The dorsal surface of specimen No. 206 (the genotype) is complete, the bones anteriorly somewhat crushed down; the other specimen (No. 207) lacks the bones surrounding the orbits. Many of the sutures can be clearly seen, and so far as they go agree well with those of *Diplocaulus*. The dermosupraoccipitals are broader, the tabulars short, the parietals broader, etc. The premaxillae are clearly defined by a median and transome sutures. Across their middle, at the margin of the skull, there is a break corresponding